Air Contamination from High-Speed Dental Drills

by G Kazantzis MB PhD FRCS (*London*)

The human respiratory tract possesses defence mechanisms which offer considerable protection against inhaled particles and aerosols. Some large particles are filtered by the hairs within the nasal cavity. Others, coming into contact with the mucous membrane of the pharynx and larynx, excite the cough reflex, and are expelled, enveloped in mucus. Smaller particles which enter the trachea and bronchial tree may come to rest on the mucosa, or may be carried to the respiratory bronchioles or the alveoli of the lung. However, not all inhaled particles are arrested by the lung. A high percentage of sub-micron particles remain entrained in the airstream, and are expelled during expiration. The arrested particles are rapidly enveloped in mucus secreted by the goblet cells of the bronchial mucosa. Some are expelled mechanically by the rhythmical beat of the ciliary epithelium, whilst the remainder are engulfed by phagocytes, and again, may either ascend this 'ciliary escalator' or else may be transported through the epithelial lining into the lymphatic system, to be deposited in regional or more distant lymph nodes. Different inhaled materials excite the phagocytic response to different degrees, and studies of the clearance rates of inhaled particles are now going on.

Alveolar deposition and retention of inhaled particles is determined mainly by their size and shape. Maximal retention takes place with particles from 0·5–5 μ in diameter, although the diameter is not the critical parameter of the particle, recent work suggesting that deposition is mainly dependent on its terminal velocity. Particles greater than 25 μ in diameter are not often seen in the alveoli, even though the diameters of these may be 80–130 μ.

Whether inhaled particles are injurious or not depends, therefore, not only on their composition, concentration and duration of exposure, but also on their size and shape. When a dental drill is used, particles are produced from the tooth – enamel, dentine, cement, carious material, bacteria and old filling materials, and also from the bur – particles of steel, tungsten carbide and diamond, although the latter will be present in very low concentrations. To all the foregoing particles droplets of water and lubricating oil are added when the air turbine is used. Small particles remain suspended in room air for many hours after their emission, and are rapidly distributed over the room as a whole by small air currents. When oil and water droplets are produced close to the source of solid particles, these and oil droplets will be found within water droplets. This will have the effect of aggregating the smaller oil droplets into larger drops, and the solid particles into larger masses, which may, however, break apart again when the water droplet dries.

In the survey performed by the Department for Research in Industrial Medicine, the air turbine drill was found to be used in a number of different ways. The investigation was restricted to an N.H.S. practice, and to the Dental Department of a London teaching hospital. The drill was seen to be used both dry (although not in the hospital), and with a water jet. The water supply being variable, the drill was sometimes used with much water, and sometimes with very little. The oil supply was also variable, and on different machines the oil drip feed rate was found to vary between 28 and 78 drops per minute. Vegetable oils, such as olive oil, almond oil, and coconut oil, are most frequently used to lubricate the turbine, but paraffin oil, which is a mineral oil, is also used to-day. The vegetable oils contain a stabilizer to prevent oxidation and increase in viscosity of the oil film.

Observation of the oil spray, at the drill head of an 'Alston' portable instrument, showed variations dependent on the oil drip feed rate. Immediately after a drop had been observed in the counting chamber, a fine mist of oil droplets was visible in a beam of light close to the turbine head. This mist decreased in intensity until the next drop was seen to fall. The mist was composed largely of droplets of about 0·5 μ diameter, but there were also some larger drops.

Atmospheric sampling was performed with the drill used 'dry' and 'wet', first on a model, and then at the chairside. The model was a brass cylinder 6 cm in diameter and 7 cm long, with the remote end sealed, in which four teeth were mounted. These were drilled continuously for 30 minutes with the 'Alston' portable instrument, both with and without a water jet.

The oil flow rate was 33 drops per minute, and the water flow 2·6 ml per minute. An air sample taken at a point one foot in front of the 'mouth' and six inches above it showed an average oil concentration of 1·3 mg oil per cubic metre of air. A second sample, taken during ten minutes of drilling showed a calcium concentration from the tooth particles of 0·10 mg per cubic metre of air. However, when the drill was used without a water jet, the calcium concentration was 1·5 mg per cubic metre of air, or 15 times the concentration attained when using the water jet. In practice, the drill would not be used for such a long period of time, so that the concentrations obtained would be lower. Microscopic examination of a cascade impactor sample showed that the greater mass of the oil and particulate matter was trapped in drops of water larger than would usually be considered respirable.

Samples were taken at the chairside, as close as possible to the operator's face (Fig 1). A fine cloud of droplets could be seen close to the patient's mouth during drilling. While the attempt was made to sample within this cloud, it was by no means always possible, owing to the short time that it was visible, and to its rapid dispersal a short distance in front of the patient's face. The actual drilling time in the preparation of a cavity was rarely found to exceed 90 seconds. Samples taken when the drill was running without water showed an oil concentration of 0·62 mg per c.m and a calcium concentration of 0·047 mg per c.m of air. These concentrations were approximately halved one yard away. For comparison, oil concentrations in the general atmosphere of a machine shop, where semi-automatic lathes were used, averaged 0·5–1·0 mg per c.m throughout the day.

Samples of oil and water droplets, and solid particles taken by means of a konimeter are shown in Fig 2. Oil droplet counts varied from a few to 180 per c.c, with an average size of one micron, but with some droplets greater than 10 µ. Solid particles varied from a very few to 170 per c.c, the average size being 1·5 µ, with occasional particles up to 150 µ.

Fig 1 *Atmospheric sampling at the chairside, using a konimeter, during the use of a high-speed dental drill*

Samples were taken in the same way while a conventional drill was in use. The concentration of solid particles during drilling was very small, but when an air syringe was used to blow out the debris in the cavity, a very much higher concentration of particles was obtained than at any time during drilling with the high speed instrument (Fig 3).

Observations on bacterial contamination during the use of the high speed drill were made by drawing air from the region of the operator's face through a slit sampler, and impinging this on a

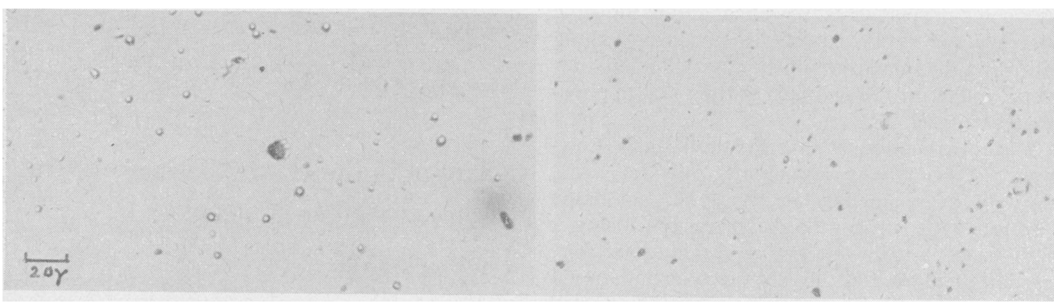

Fig 2 *Samples of oil and water droplets and solid particles*

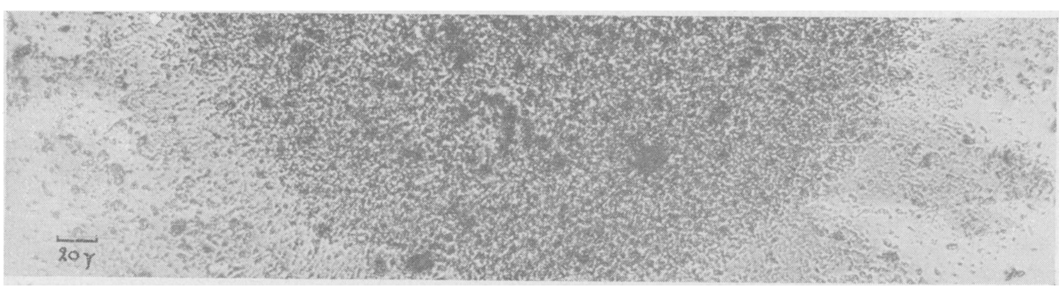

Fig 3 *Samples of solid particles taken after blowing out with an air syringe*

rotating blood agar plate. Samples were taken before, during and after drilling with both high speed and conventional instruments. The periods during which drilling was performed could be identified on the plates as tooth debris could be seen in the appropriate segment. A uniform distribution of aerial contaminants was seen, the predominant organisms being *Staphylococcus albus* and a Gram-negative bacillus of the aerogenes group. Some periods of drilling were associated with a growth of *Streptococcus viridans* organisms. These were found following the use of both high speed and conventional drills, and were the only organisms to be specifically associated with drilling procedures, although sampling was related to a number of patients on different days in the two dental surgeries investigated.

From these observations, it was thought that there was no increased risk to the operator of bacterial contamination associated with the use of the high speed drill. It was found that the quantity of respirable dust produced by the high speed drill was small, especially when it was used with a water jet, and when not only the concentration, but also the total time of exposure to the peak concentration was taken into account.

Consideration of the composition of the solid particles does not reveal the presence of any substance that might be considered to be pathogenic in the concentrations encountered. The silicates found in amalgam fillings do not have the same fibrogenic properties as free silica, and pathogenic effects would not be expected to occur in the lung following the inhalation of the crystalline apatites which make up the enamel, or the calcium phosphates of bone.

The introduction of oil into the lung is, however, by no means innocuous. Oils have the capacity of producing a granulomatous tissue reaction with surrounding fibrosis, producing a hard mass known as an oleogranuloma. The inhalation of animal oils produces an inflammatory reaction in the lung with many multinucleated foreign body giant cells and large mononuclear cells with oil laden cytoplasm. A dense wall of connective tissue may in time be laid down round these clusters of cells. The reaction may be acute and produce pneumonic consolidation followed by resolution. Such lesions have been demonstrated in children who have inhaled cod-liver oil.

Mineral oils produce a slower but intense fibrous tissue reaction surrounding collections of oil laden macrophages. Firm masses develop in the lung which may superficially resemble a malignant lesion, termed descriptively, a paraffinoma. Chronic respiratory symptoms are often produced. Many such cases have been described following the inhalation of liquid paraffin administered medicinally (Ikeda 1937, Proudfit *et al.* 1950, Symmers 1955, Forbes & Bradley 1958).

Vegetable oils, if free from fatty acids, rarely produce an inflammatory reaction in the lung. The oil droplets are usually broken up and removed via the lymphatic system by phagocytes, so that eventually no trace of oil is left. Iodized vegetable oils are commonly introduced into the lung for radio-diagnostic purposes, and ill effects associated with these oils have rarely been reported (Pinkerton 1928, Santé1949).

It is recommended that vegetable oils free from impurity should be used exclusively for lubricating purposes in air turbine drills. The minimum quantity compatible with efficient running of the machine should be used. If the instrument is used with a water jet there will be an appreciable reduction in air contamination with solid particles, so that apart from any consideration concerning the safety of the tooth operated upon, the safety of the dental surgeon operating the drill is also made more certain.

Acknowledgments: I would like to thank Professor C F Barwell for bacteriological facilities and for interpreting the bacteriological sampling results, Dr A I G McLaughlin for his generous advice, and Mr E King for performing the atmosphere sampling tests.

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Changes in the Dental Tissues due to Cavity Preparation using a Turbine Handpiece

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Two years ago it was decided to investigate the tissue changes that might follow cavity preparation using a turbine handpiece. The main purpose was to determine the effects of such instrumentation upon the pulp. However, unexpected findings during the course of the investigation led to a widening of the scope of the experiments, firstly to include changes that were observed in the dentine, and more recently to explore the possibility of changes in the enamel.

For the investigation into changes in the pulp, it was thought desirable to use both diamond points and tungsten carbide burs, and to compare the response following cutting under waterspray